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Design and Implementation of an Examination Information System by Object-Oriented Programming

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Abstract

An examination information system for policemen in Taiwan was built up by using object-oriented technology, including object-oriented analysis, object-oriented design and C++ programming. A set of reusable class libraries developed in III are applied to implement the design. The reusability of these class libraries in this system is about 75%. The first version of this system is built up with only three man-months. Currently, this system is being extended to cover other examinations.

Keywords: OO Programming, OO Software Development, Software Reuse

1. Background

The Ministry of Examination (MOEX) in Taiwan was set up in 1989 to handle the examination and qualification of the employees of government. The job of examination and qualification is quite complex in this country. There are many different examinations and qualification testings held each year. Furthermore, the differences between examinations are quite large and the process of each examination is tedious. Coming with the expansion of the government organization, the load of MOEX is heavier every year. How to speed up the process of each examination is quite important for MOEX. At May of 1992, the information management office of MOEX submitted a proposal about examination information management and office automation of MOEX to government [1]. This proposal was accepted. As the largest software house in Taiwan, Institute for Information Industry (III) was invited to give the detailed execution plan about this proposal. Parallel with the detail planning, the object-oriented technology team (OOT team) in III was assigned to involve in this project to speedup the development of the system by applying object-oriented technology.

2. Introduction

The proposal submitted by MOEX to government is quite complex. It includes examination operation computerization, general administration management, information management, and decision supporting system. After about one month of evaluation process, the OOT team decided to develop an examination information system for policemen as a pilot project. After this system is built up, the class libraries developed in this system can be reused to develop other examination information systems.

In this paper, we will present the design and implementation of this system. The rest of this paper is organized as follows. In section 3, we will give a brief description of the operations taken by MOEX to give an examination. Then, in section 4, our design and implementation will be described. The results of our implementation will be discussed in section 5. Finally, the lessons learned in this project and the future works will be discussed in section 6.

3. The Operations for an Examination

In this section, we will give a rough description of the operations taken by MOEX to give a typical examination. Roughly, to

give an examination, the MOEX should go through the steps listed as follows:

- Step 1: Preparation
Survey the needs of the government departments to determine the number of personnel needed and the examinations should be given in next year. Since the number of government departments is quite large and the qualification for each position in a department is different to each other, this survey will take a long time to make a conclusion and the types of examinations should be given are also very complicated.
- Step 2: Process applications for examination
Usually, MOEX announces the schedule of each examination for the next year at a time. About one month before a specific examination, the MOEX should accept and review the application forms for attending the examination, key in the data about the applicants, and invite the proper professors from academy to give the examination questions.
- Step 3: Sealing the examination paper and giving the examination
MOEX allocates the working spaces to seal each examination paper and another spaces to give the examination. Since the number of people attending the government examination is quite large, the spaces is always a big problem. Figure 1 shows the number of examinees in the recent years.
- Step 4: Give the score
Normally, each examination is composed of two types of examination questions. The first type is the "choosing the correct answer" examinations. Computer readable cards can be used for this type of examinations and then can be read into computer to calculate the scores. Another type of question is written examinations and should be reviewed by examiners to give the scores. At least two examiners are invited to review a same sheet and if the difference between these two scores is out of tolerance, the third person should be invited to review it and make a judgment.
- Step 5: Announcement
Announce the people who pass the examination and give the certificates. The listing and related personal information will be sent to government for filing.

4. New System

4.1 The III class libraries

Since the beginning of 1992, the OOT team in III devoted to develop a set of class libraries for memory management and human interface handling. A characteristic of these libraries is that they can support multi-platform development. That is, any application reusing these class libraries to handle the human interface will be able to support the DOS graphic characters version, MS-Windows version and Motif version at the same source codes. The Windows version of the libraries is ready at the time of this paper is prepared and the DOS graphic characters version and Motif version are under development and scheduled to complete at this June.

To speed up the development of the examination information system and to give a friendly user-interface of the system, these class libraries are utilized in the development. Portion of these class libraries is illustrated in Figure 3. The class tree rooted by NObj can give the persistence capability to an object. The tree rooted by HIObj is used to handle the human interface.

4.2 The policemen examination information system

The policemen examination information system is chosen as a pilot project by the OOT team to demonstrate the OO software development in this project. Rapid prototyping technique is applied to develop this system. About one week after the meeting held between OOT team engineers and personnel in MOEX to discuss the operations and requirements of this system, the first version of prototype was put on the desk for discussion. Further two weeks later, the second prototype with most of the required functionality supported was ready and the MOEX was quite surprised about the development speed. The final product was scheduled to complete in the middle of this March.

There are several different *fields* of examinations held by MOEX. For example, there are examinations for policemen, for telecom engineers, for computer operators, ..., etc. For each field of examination, there are several *items* of topics to give the questions. Some items may appear in several different fields of examinations. For example, for policemen examination, the items of topics include "laws of traffics," "Chinese," ..., etc. And the "Chinese" examination almost appears in every field of examination.

The top level of class diagram of this design is shown in Figure 2. The notations proposed by Grady Booch in [2] are utilized to make the design notation. The classes in this design are described as follows:

- **FieldDict:** This is a dictionary containing the fundamental information about each specific field. The related items of each field are collected in a FieldItem class. FieldItem will reference the ItemDict class to get more detailed information of each item.
- **ItemDict:** This dictionary contains the detailed information about all items. Each item may be related to some different fields listed in the FieldDict dictionary.
- **ExamineeScoreDict:** The ExamineeScoreDict collects the score for each examinee, which is recorded in a specific ExamineeScore object for each examinee.
- **FieldStatistics:** For each field, we should support some statistic's data for feeding back to the examiner for verifying whether the difficulty of the questions is proper for this examination. The field information and examinee score records should be referenced to generate this report.
- **FieldSecretNoDict:** Each applicant to an examination is assigned a *secret number* to keep the detail information from the examiners so that the examination can be kept impartial. These numbers will be used in the processing to represent the examinees. This class handles the operations about the secret numbers of applicants applying for a specific field of examination.
- **TestScoreDict, CardDict and ItemScore:** Two scores are kept for each examinee. One is for computer-readable cards and the other is for hand-written test score. The former of the scores is recorded in CardDict and the latter is in TestScoreDict. ItemScore references these two scores to determine the score for a specific item.
- **ExamineeDict:** The detailed information of each examinee is recorded in ExamineeDict.
- **PassedExaminee:** This class references the

ExamineeScoreDict to determine the examinees that pass this examination and then checks the ExamineeDict to get the information about each passed examinee to generate the listing and printed out the certificates.

5. Results Achieved

Shown in Figure 3 is partial of the class hierarchy of this system. The classes with shaded background are specific to this examination system. Those with italic style are those inheriting from the classes supported by III class libraries with slight modification. The rest are the major portion of III class libraries.

This system is implemented in Borland C++ 3.1 and runs under MS-Windows. Shown in Figure 4 is the operation of this system.

Totally, there are about one hundred classes in the system. About 15 of them are brand new classes. Further, about 20 of the other classes directly inherit from the classes supported by III class libraries and with slight modification. The reusability of III class libraries in this system is roughly estimated as

$$\begin{aligned}
 & ((\# \text{ classes in system}) - (\# \text{ brand new classes}) - \\
 & (\# \text{ classes directly inherit from the III class libraries}) * 50 \%) \\
 & * 100\% \\
 & = (100 - 15 - 20 * 50\%) * 100\% \\
 & = 75\%.
 \end{aligned}$$

6. Summary

A set of reusable class libraries is utilized to develop an examination information system under MS-Windows. The examination information system for policemen was completed within three man-months. The result is quite encouraging. It was observed that the most important capabilities of these libraries to this design are persistence capability and human-interface handling capability.

Currently, the OOT team is developing the Motif version and DOS graphic characters version of the class libraries. At the same time, the class libraries generated from the policemen examination information system will be reused by another team to develop other examination information systems. At the completeness of Motif version of III class libraries, these systems will be ported to workstations.

References

- [1] MOEX, Proposal for examination information and office automation in Ministry of Examination, Ministry of Examination, Taiwan, ROC, May, 1992
- [2] Grady Booch, Object-Oriented Design with Applications, Benjamin/Cummings, 1991

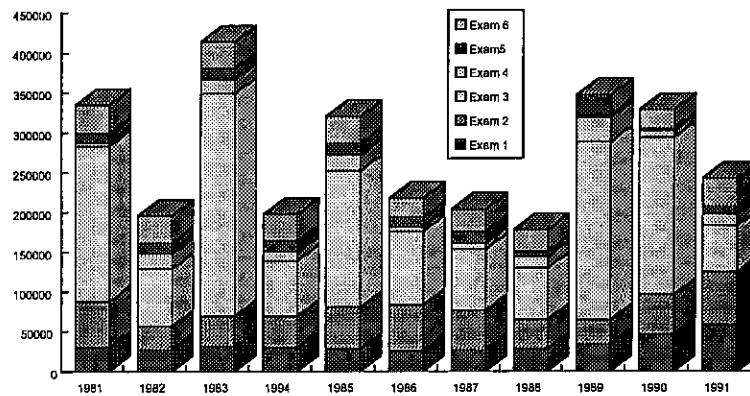


Figure 1. Number of examinees in the recent years

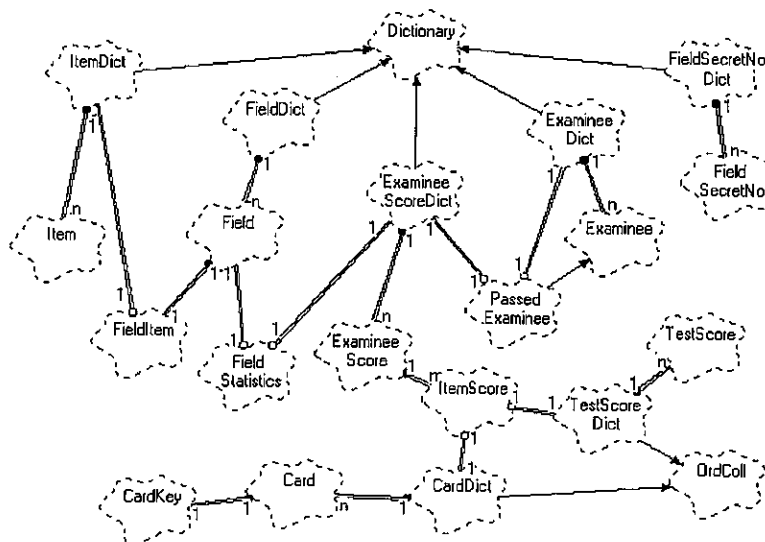


Figure 2. Top level of class diagram

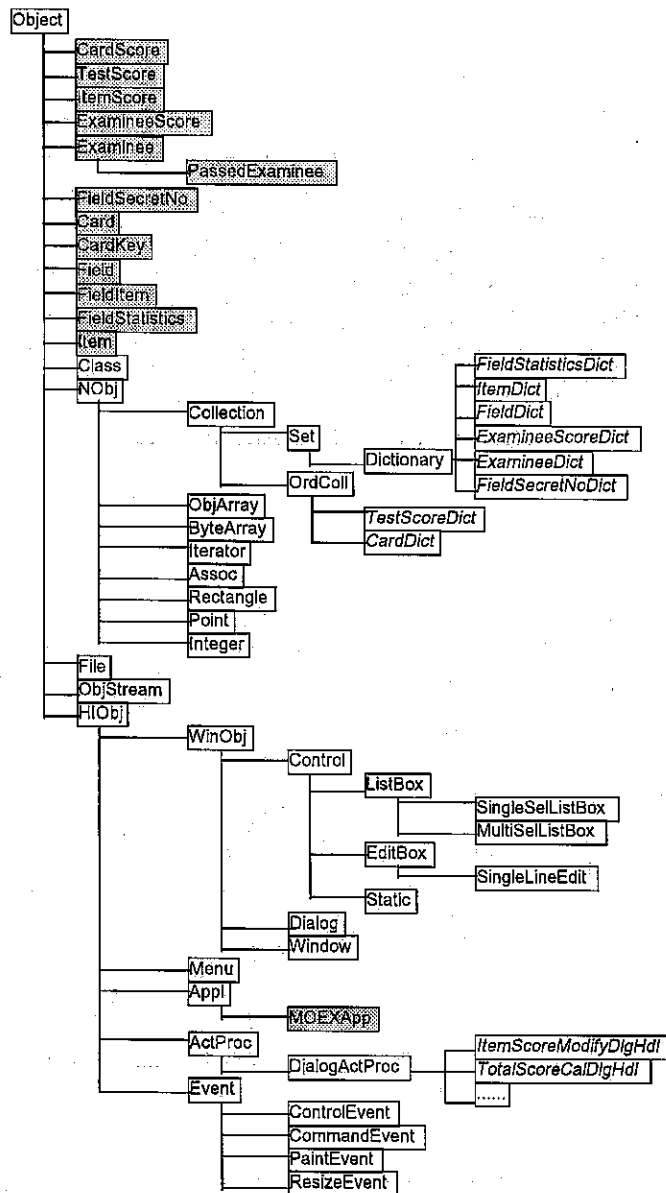


Figure 3. Class hierarchy of policemen examination information system

警察考試系統

科目建檔作業 | 卡柱成績處理 | 總成績計算 | 成績統計 | 放榜作業

類科資料維護...
科目資料維護...
考生資料維護
類科部屬資料維護

類科維護

類科代號

11001	*
12001	*
13001	
14001	
15001	
16001	
17001	
21001	
22001	*

新增
刪除
修改
查詢
關閉

類科部屬維護

類科代號: 12001
類科代字: 外事
類科名稱: 外事警察人員
共同科目百分比: 15
專業科目百分比: 85
錄取最低分: 60.00
錄取名額: 0

類科部屬科目代號

A001
A003
A006
A009
A010
A011
C001
C002

新增一應試科目
修改一應試科目
刪除一應試科目
關閉

Figure 4. Operation of policemen examination information system